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Modelling of thermoelectric generators for satellite application

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Current studies in design of thermoelectric generators (TEGs) are mostly disconnected to the parametric optimization of the TEG, and realistic mechanical and thermal boundary conditions. In this study, a three dimensional (3D) model is used to design, optimize and study potential TEGs intended for satellite applications. This model takes into account the real boundary conditions of space application such as spatial constraints, maximum allowable internal resistance and temperatures on the cold and hot junctions. The temperature dependent thermoelectric properties of Bi₂Te₃-based materials are used as input parameters. The numerical model used to solve the system is based on the finite element commercial software, COMSOL. The optimal geometrical dimensions, including the dimensions of the thermoelectric legs, the number of unicouples and module fill factor (effective cross-section area of thermoelectric materials) are calculated through an optimization process. The 3D model also considers the influence of contact resistance on power generation by inclusion of experimentally obtained contact resistance data. Furthermore, this study investigates thermal stress and displacement of the thermoelements under practical thermal and mechanical boundary conditions. The simulations are based on optimal load resistance that provides the maximum power in the TEGs. The results of this study show detailed 3D information of TEG optimal geometry, temperature distribution, voltage generation, electric voltage generation, total current density, effect of actual contact resistance on power generation, bounding stress and displacements of the thermoelements in the TEGs.